IONIZING RADIATION: SOURCES AND EXPOSURES

Purpose:

This lesson will introduce students to sources of ionizing radiation and explain how much exposure the average U.S. citizen receives from various sources annually. The lesson will help students put radiation associated with nuclear fuel cycle activities (i.e., all those steps associated with generating electricity at nuclear powerplants, from mining to waste disposal) in perspective.

Concepts:

1. Ionizing radiation is energy in the form of electromagnetic waves or fast-moving particles.
2. Ionizing radiation is part of our natural environment but also can result from human activities.
3. Ionizing radiation from natural sources contributes more than 80 percent to the average exposure of 360 millirem of an individual residing in the United States.

Duration of Lesson:

Two 50-minute class periods

Objectives:

As a result of participation in this lesson, the learner will be able to:

1. define ionizing radiation;
2. name both natural and manmade sources of ionizing radiation;
3. state how many millirem of exposure to radiation the average American receives annually;
4. state what percentage of exposure of the average American to ionizing radiation is from natural sources;
5. state approximately how many millirem of exposure to ionizing radiation he/she personally received this year; and
6. name the sources of his/her personal exposure.

Skills:

Calculating, reading, reading and interpreting graphs and tables

Vocabulary:

Acute exposure, alpha particle, background radiation, beta particle, cancer, cosmic radiation, decay product, electromagnetic spectrum, electron, erg, frequency, gamma ray, genetic effect, ion, ionization, ionizing radiation, millirem, nuclear fuel cycle, radiation, radioactive decay, radioisotope, radon, rem, terrestrial radiation, uranium, X-ray

Materials:

Reading Lesson

Ionizing Radiation: Sources and Exposures, p. SR-1

Activity Sheets

Ionizing Radiation Exposure in the United States, p. 101

Calculating Your Personal Radiation Exposure, p. 103

Transparencies

DNA Molecule, p. 91

Cancer Risk Versus Radiation Exposure, p. 93

Radiation Exposure Pathways, p. 95

Electromagnetic Spectrum, p. 97

Radiation Paths in Tissue, p. 99

Videotape

Radiation: Fact and Myth, 22 minutes **(available free of charge from the OCRWM National Information Center, 1-800-225-6972; within Washington DC, 488-6720)**

Background Notes

Radiation Exposure, p. 16

Suggested Procedure:

1. You may want to introduce this topic by showing the videotape entitled *Radiation: Fact and Myth.* It might be wise for students to take notes as they view the film to facilitate discussion of the video's key themes.

Sample videotape questions - *Radiation: Fact and Myth*

a.) What happens during radioactive decay?

b.) How is ionizing radiation different from other radiation?

c.) How can we detect radiation?

d.) What is the most penetrating type of ionizing radiation? the least penetrating?

e.) How can we reduce our exposure to radiation?

f.) What are some sources of radiation?

g.) What are some uses of radiation?

h.) What are some concerns about radiation?

2. The vocabulary introduced in this lesson is extensive. Depending on the group, it might be helpful to preview vocabulary before beginning the reading lesson.
3. Assign the reading entitled *Ionizing Radiation: Sources and Exposures*. Before students begin, briefly preview the reading by going over the questions in the margins to focus their attention on the topics that will be covered. Allow students 30 minutes to complete the reading, and then discuss it.
4. Assign the reading review entitled *Ionizing Radiation Exposure in the United States*. When the students have completed the review exercises, you may use the sample discussions questions

below for class discussion. Following the class discussion have students complete *Calculating Your Personal Radiation Exposure.*

Sample Discussion Questions:

1. What is ionizing radiation? What are some important forms of ionizing radiation?

   (Ionizing radiation is high-energy radiation that has the ability to knock electrons out of atoms and molecules, creating charged particles called ions.

   Some important forms of ionizing radiation are cosmic rays, the X-rays produced by X-ray machines, and the alpha and beta particles and gamma rays and X-rays emitted by radioactive materials.)

2. All electromagnetic radiation (e.g., radio and television waves, microwaves, visible light, X-rays, gamma rays, etc.) travels at the speed of light. Looking at the electromagnetic spectrum, what property appears to determine whether electromagnetic radiation is non-ionizing or ionizing?

   (As you proceed across the spectrum from left to right, the frequency, in cycles per second, of the electromagnetic radiation increases and the radiation becomes higher in energy.

   NOTE: As the frequency increases, the wavelength—the distance covered by one cycle—decreases. The wavelength is equal to the velocity of light divided by the frequency.)

3. Discuss the various pathways by which people are exposed to ionizing radiation in everyday living.

   (Pathways of exposure are shown in the figure "Radiation Exposure Pathways." Pathways illustrated include cosmic radiation, indoor air and structural radiation, airborne radioactive pollutants, or dissolved radioactive pollutants. Cosmic radiation can reach people directly. Indoor air contains radon. Structural radiation refers to radiation from building materials, like bricks, that are made of materials that contain radioactive materials. Airborne or dissolved pollutants can reach people through the food chain or directly through inhalation or ingestion.)

4. The average American is exposed to about 360 millirem of ionizing radiation per year. Discuss the various sources and the amounts they contribute, in millirem, and in terms of the percentage of the total exposure.

   (The table of exposures and the pie chart of percentages can supply information for a good discussion. The discussion can be tied in with the reading reviews and the personal exposure chart students can complete. It may be interesting to ask students whether the percentages are surprising to them or what they expected.)

5. Radon, a naturally occurring radioactive gas, contributes a significant percentage to the average individual's annual exposure to ionizing radiation. If your family tested your home

and discovered unacceptable levels of radon present, what could you do to reduce your family's exposure?

(Increase ventilation in the house, especially in the basement.)

6. Some of the foods we eat contain radioactive isotopes. Should we be concerned and take care to avoid these foods? Why or why not?

   (No. To function properly, our bodies require potassium, a main source of our internal exposure to ionizing radiation.)

7. Our bodies can usually repair damage associated with low exposures to ionizing radiation comparable to the radiation we receive from natural sources or ordinary medical X-rays. Why then are we concerned with minimizing exposures to even these small exposures?

   (Many things cause cancer or genetic effects. These effects cannot be distinguished from those caused by radiation. A burn from radiation, for instance, looks like any other burn. We cannot prove that there is no negative health effect from low exposures. Therefore, some small risk is assumed for even low levels of exposure.)

8. Alpha particles can be stopped by a sheet of paper and beta particles by a thin aluminum metal. Gamma rays and X-rays deposit much less energy per unit path in human tissue than the particles. Why, then, is it necessary to store and ship spent fuel in heavy shielded casks?

   (While individual gamma rays or X-rays deposit only small amounts of energy along their path, the very large number of rays coming from spent fuel are such that their many intersecting paths in human tissue create localized areas of ionization that cause severe biological damage. Therefore, the shielded casks are necessary to reduce exposure to radiation from the spent fuel to acceptable levels.)

9. It is easier to detect the presence of radioactive materials than it is to detect the presence of other hazardous materials. Why is this important in waste management and disposal?

   (The presence of most hazardous materials must be detected chemically. To do this, you need more of the hazardous material than you would need to detect a radioactive substance. The procedures and equipment for chemical identification are more suitable for the laboratory than the field. Radiation detection instruments cannot only detect extremely small quantities of radioactive materials, but they are also ideal for use as monitors in the field. These factors improve safety by enabling us to monitor readily.)

Teacher Evaluation of Learner Performance:

Student participation in class discussions and completion of the reading review entitled *Ionizing Radiation Exposure in the United States* and the activity *Calculating Your Personal Radiation Exposure* will indicate understanding.

Enrichment:

Radioactivity in Food, p. 119
Jet Flight Exposure, p. 123
Cosmic Radiation, p. 125

Apollo Flight Exposure, p. 127
Manmade Radiation Sources, p. 129
Biological Effects of Ionizing Radiation, pp. SR-21, 131

Radiation is a subject many students may be concerned about. Either after this lesson or after students have completed the enrichment lesson entitled *Biological Effects of Ionizing Radiation*, arrange for someone in the community who works with radioactive materials to come to speak to the class. Your local hospital, a university or college, or a utility that operates a nuclear powerplant are all good sources for speakers. Students can prepare for a speaker by writing questions about radiation that they would like to have answered. The questions can either be submitted to the speaker in advance or can be asked at the time of the visit.